CHAPTER II - RECONNAISSANCE AND FIXES

1. GENERAL

The Joint Typhoon Warning Center depends on reconnaissance to provide necessary, accurate, and timely meteorological information in support of each warning. JTWC relies primarily on three reconnaissance platforms: aircraft, satellite, and radar. In data rich areas synoptic data are also used to supplement the above. Optimum utilization of all available reconnaissance resources is obtained through the Selective Reconnaissance Program (SRP); various factors are considered in selecting a specific reconnaissance platform including capabilities and limitations, and the tropical cyclone's threat to life and property both afloat and ashore. A summary of reconnaissance fixes received during 1985 is included in Section 6 of this chapter.

2. RECONNAISSANCE AVAILABILITY

a. Aircraft

Aircraft weather reconnaissance for the JTWC is performed by the 54th Weather Reconnaissance Squadron (54th WRS) located at Andersen Air Force Base, Guam. The 54th WRS is presently equipped with six WC-130 aircraft and, from July through October, is normally augmented by two additional aircraft from the 53rd WRS, Keesler Air Force Base, Mississippi, bringing the total number of available aircraft to eight. The JTWC reconnaissance requirements are provided daily to the Tropical Cyclone Aircraft Reconnaissance Coordinator (TCARC), who marries the tasking from the JTWC with the available airframes from the 54th WRS.

As in previous years, aircraft reconnaissance provides direct measurements of standard pressure-level height, temperature, flight-level winds, sea-level pressure, estimated surface winds (when observable), and numerous additional parameters. The meteorological data are gathered by the Aerial Reconnaissance Weather Officer (ARWO) and dropsonde operators of Detachment 3, 1st Weather Wing who fly with the 54th WRS. These data provide the Typhoon Duty Officer (TDO) with indications of tropical cyclone position and intensity. Another important aspect is the availability of the data for technique development and tropical cyclone research.

b. Satellite

Satellite fixes from USAF/USN ground sites and USN ships provide day and night coverage in the JTWC area of responsibility. Interpretation of this satellite imagery provides tropical cyclone positions and estimates of current and forecast intensities through the Dvorak technique.

c. Radar

Land radar provides positioning data on well developed tropical cyclones when in the proximity (usually within 175 nm (324 km)) of the radar sites in the Philippines, Taiwan, Hong Kong, Japan, South Korea, Kwajalein, and Guam.

d. Synoptic

JTWC also determined tropical cyclone positions based on the analysis of the surface/ gradient level synoptic data. These positions were helpful in situations where the vertical structure of the tropical cyclone was weak or accurate surface positions from aircraft of satellite were not available.

3. AIRCRAFT RECONNAISSANCE SUMMARY

During 1985, JTWC levied requirements for 192 vortex fixes and 59 investigative missions of which 12 were flown into disturbances that did not develop. In addition to the levied fixes, 167 intermediate fixes were also obtained. Eighteen synoptic missions were requested and flown to provide mid-level steering information. The average vector error for all aircraft fixes received at the JTWC during 1985 was 11 nm (20 km).

Aircraft reconnaissance effectiveness is summarized in Table 2-1 using the criteria set forth in CINCPACINST 3140.1 (series).

4. SATELLITE RECONNAISSANCE SUMMARY

The Air Force provides satellite reconnaissance support to JTWC using imagery from a variety of spacecraft. The tropical cyclone satellite surveillance network consists of both tactical and centralized facilities. Tactical DMSP sites are located at Nimitz Hill, Guam; Clark AB, Republic of the Philippines; Kadena AB, Japan; Osan AB, Korea; and Hickam AFB, Hawaii. These sites provide a combined coverage that includes most of the JTWC area of responsibility in the western North Pacific from near

TABLE 2-1. AIRCRAFT RECONNAISSANCE EFFECTIVENESS

EFFECTIVENESS	NUMBER OF LEVIED FIXES	PERCENT
COMPLETED ON TIME	174	90.6
EARLY	4	2.1
LATE	4	2.1
MISSED	10	5.2
TOTAL	192	100.0

LEVIED VS. MISSED FIXES

	LEVIED	MISSED	PERCENT
AVERAGE 1965-1970	507	10	2.0
1971	802	61	2.0
1972	624	126	20.2
1973	227	13	5.7
1974	358	30	8.4
1975	217	7	3.2
1976	317	11	3.5
1977	203	3	1.5
1978	290	2	0.7
1979	289	14	4.8
1980	213	4	1.9
1981	201	3	1.5
1982	276	17	6.2
1983	157	3	1.9
1984	210	2	1.0
1985	192	10	5.2

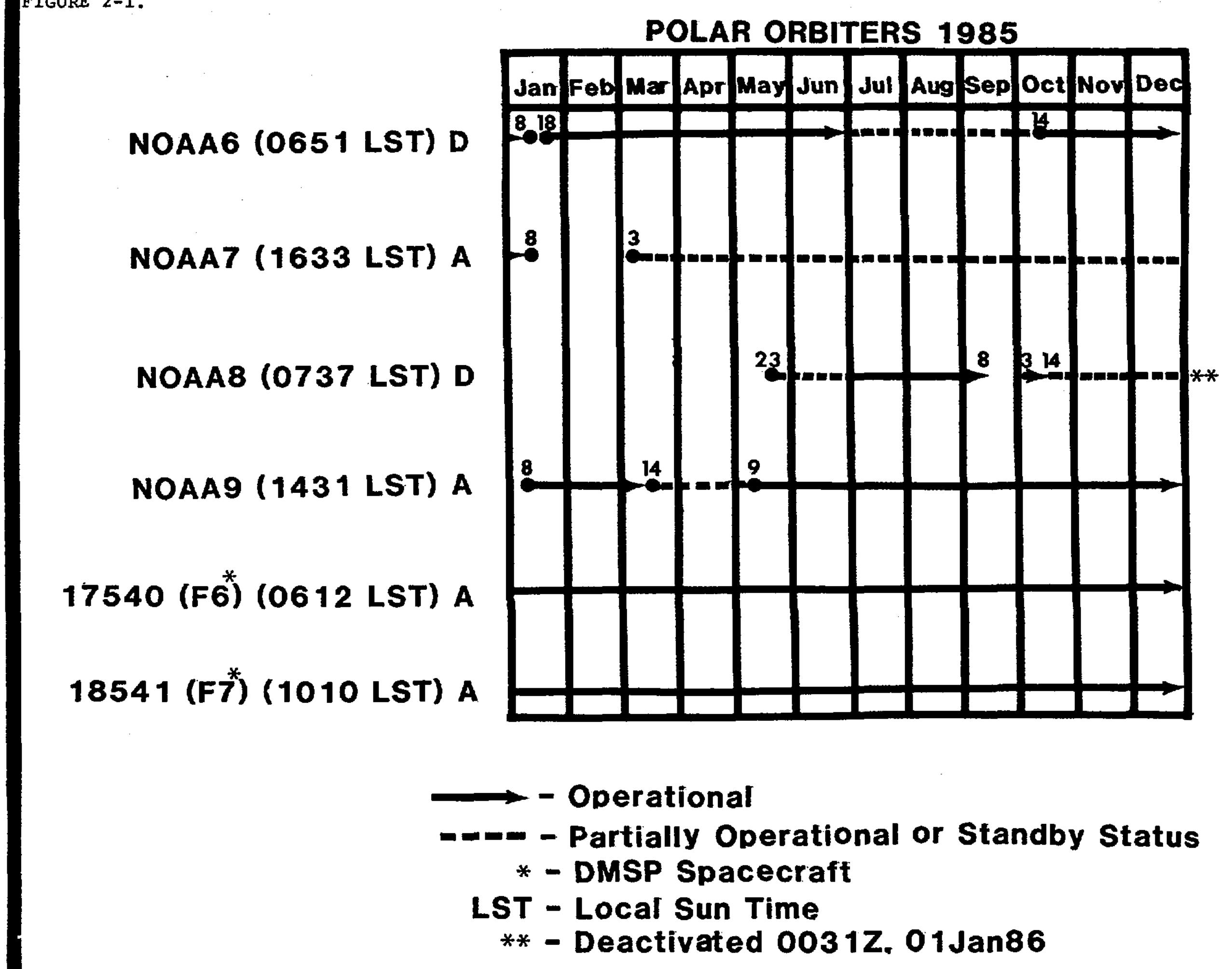
the dateline westward to the Malay Peninsula. JTWC relies on the Air Force Global Weather Central (AFGWC) to provide coverage over the remainder of its area of responsibility using stored satellite data. The Naval Oceanography Command Detachment, Diego Garcia, provides NOAA polar-orbiting coverage in the central Indian Ocean as a supplement to this support. U.S. Navy ships equipped for direct readout also provide supplementary support.

AFGWC, located at Offutt AFB, Nebraska, is the centralized member of the tropical cyclone satellite surveillance network. In support of JTWC, AFGWC processes stored imagery from DMSP and NOAA spacecraft. Imagery processed at AFGWC is recorded onboard the spacecraft as it passes over the earth. Later, these data are downlinked to AFGWC via a network of command readout sites and communication satellites. This enables AFGWC to obtain the coverage necessary to fix all tropical systems of interest to JTWC. AFGWC has the primary responsibility to provide tropical cyclone surveillance over the entire Indian Ocean, southwest Pacific, and the area near the dateline. Additionally, AFGWC can be tasked to provide tropical cyclone positions in the entire western North Pacific as backup to coverage routinely available in that region.

The hub of the network is Det 1, 1WW, collocated with JTWC on Nimitz Hill, Guam. Based on available satellite coverage, Det 1 coordinates satellite reconnaissance requirements with JTWC and tasks the individual network sites for the necessary tropical cyclone fixes. When a position from a polar-orbiting satellite is required as the basis for a warning, it is called a "levied fix". To satisfy the "levied fix", two sites are tasked to fix the tropical cyclone from the same satellite pass. This provides the necessary redundancy to virtually guarantee JTWC a successful satellite fix on the tropical cyclone. Using this "dual-site" concept, the satellite reconnaissance network is capable of meeting all of JTWC's levied satellite fix requirements.

The network provides JTWC with several products and services. The main service is one of surveillance. Each site reviews its daily satellite coverage for indications of tropical cyclone development. If an area exhibits the potential for development, JTWC is notified. Once JTWC issues either a formation alert or warning, the network is tasked to provide three products: tropical cyclone positions, intensity estimates, and 24-hour intensity forecasts. Satellite tropical cyclone positions are assigned Position Code Numbers (PCN) to indicate the accuracy of the fix position. This is dependent upon the availability of visible landmarks in the image for precise gridding, and the degree of organization of the tropical cyclone's cloud system (Table 2-2). During 1985, the network provided JTWC with a total of 2505 satellite fixes on tropical systems in the western North Pacific. This is a record number of fixes for the year. Another 195 fixes were made for tropical systems in the North Indian Ocean. A

FIGURE 2-1.



comparison of those fixes of numbered tropical cyclones in the western North Pacific with their corresponding JTWC best track positions is shown in Table 2-3a (Comparison of fixes with the corresponding best track for the South Pacific and Indian Oceans is presented in Table 2-3b). Estimates of the tropical cyclone's current intensity and 24-hour intensity forecast are made every 12 hours by applying the Dvorak technique (NOAA Technical Report NESDIS 11) to visual and enhanced infrared imagery.

Figure 2-1 shows the status of operational polar orbiting spacecraft. Six were available at various times in 1985. NOAA 6 suffered low power problems from the 8th of January to the 18th. It continued to operate with degraded imagery until July, when it was placed on standby and replaced by the repaired NOAA 8. NOAA 8 suffered from continuing oscillator problems until finally deactivated on 1 January 1986, leaving NOAA 6, once again, as the primary morning spacecraft. NOAA 7 was placed on standby March 3rd after operating with impaired high resolution picture transmissions (HRPT) since 8 January. It was replaced by NOAA 9, (launched 12 December 1984) which became fully operational 9 May. At the end of the year, NOAA 9 was the only fully operational NOAA satellite.

TABLE 2-2. POSITION CODE NUMBERS

PCN	METHOD OF CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL DEFINED CC/GEOGRAPHY
4	WELL DEFINED CC/EPHEMERIS
5	POORLY DEFINED CC/GEOGRAPHY
6	POORLY DEFINED CC/EPHEMERIS

5. RADAR RECONNAISSANCE SUMMARY

Seventeen of the 27 significant tropical cyclones in the western North Pacific during 1985 passed within range of land-based radar with sufficient cloud pattern organization to be fixed. The land radar fixes that were obtained and transmitted to JTWC totaled 1360. Three radar fixes were obtained by reconnaissance aircraft.

The WMO radar code defines three categories of accuracy: good (within 10 km (5nm)), fair (within 10-30 km (5-16 nm)), and poor (within 30-50 km (16-27nm)). Of the 1091 radar fixes coded in this manner; 299 were good, 413 were fair, and 379 were poor. Compared to the JTWC best track, the mean vector deviation for land radar sites was 13 nm (24 km). Excellent support through timely and accurate radar fix positioning allowed JTWC to track and forecast tropical cyclone movement through even the most difficult erratic tracks.

As in previous years, no radar reports were received on North Indian Ocean tropical cyclones.

TABLE 2-3b. MEAN DEVIATION (NM) OF ALL SATELLITE DERIVED TROPICAL CYCLONE POSITIONS IN THE SOUTH PACIFIC AND SOUTH INDIAN OCEANS. NUMBER OF CASES IN (PARENTHESES).

PCN	1985 (ALL SITES)	
1	15.8	(20)
2	15.5	(168)
3	26.1	(42)
4	29.2	(190)
5	46.9	(241)
6	39.8	(1140)
1&2	15.5	(188)
3&4	28.7	(232)
5&6	41.1	(1381)
TOTAL NUMBER OF CASES		(1801)

6. TROPICAL CYCLONE FIX DATA

A total of 4268 fixes on 27 western North Pacific tropical cyclones and 195 fixes on 6 North Indian Ocean tropical cyclones were received at JTWC. Table 2-4a, Fix Platform Summary, delineates the number of fixes per platform for each individual tropical cyclone. Season totals and percentages are

TABLE 2-3a. MEAN DEVIATION (NM) OF ALL SATELLITE DERIVED TROPICAL CYCLONE POSITIONS FROM THE JTWC BEST TRACK POSITIONS IN THE WESTERN NORTH PACIFIC AND NORTH INDIAN OCEANS. NUMBER OF CASES (IN PARENTHESES).

	WESTERN NORTH PACIFIC OCEAN				NORTH INDIAN OCEAN			
	1975-1984 AVERAGE		1985		1980-1984 AVERAGE		1985	
PCN	(ALL SITES)		(ALL SITES)		(ALL SITES)		(ALL SITES)	
1	13.3	(1505)	17.7	(127)	16.7	(40)	----	(0)
2	17.0	(1617)	13.2	(175)	18.9	(7)	----	(0)
3	20.6	(2176)	24.8	(191)	21.4	(13)	11.5	(8)
4	23.9	(1000)	19.5	(300)	64.6	(8)	33.1	(2)
5	37.4	(4070)	37.0	(311)	34.8	(171)	28.9	(49)
6	42.4	(2278)	32.8	(972)	41.1	(106)	33.6	(97)
1&2	15.2	(3122)	15.1	(302)	17.2	(47)	----	(0)
3&4	21.6	(3176)	21.6	(491)	41.3	(21)	15.8	(10)
5&6	39.2	(6348)	33.8	(1283)	36.1	(277)	32.1	(146)
TOTAL NUMBER OF CASES		(12646)		(2076)		(345)		(156)

TABLE 2-4a. FIX PLATFORM SUMMARY FOR 1985.

FIX PLATFORM SUMMARY

WESTERN NORTH PACIFIC		AIRCRAFT	SATELLITE	RADAR	SYNOPTIC	TOTAL
TS ELSIE	(01W)	3	23	-	1	27
TS FABIAN	(02W)	7	82	-	8	97
TY GAY	(03W)	10	127	-	-	137
TD	(04W)	-	40	-	4	44
TY HAL	(05W)	12	119	79	4	214
TY IRMA	(06W)	22	110	83	-	215
TY JEFF	(07W)	23	180	99	12	314
TY KIT	(08W)	29	165	289	4	487
TS LEE	(09W)	10	61	28	-	99
TY MAMIE	(10W)	2	70	9	7	88
TY NELSON	(11W)	20	113	141	1	275
TY ODESSA	(12W)	31	135	144	-	310
TY PAT	(13W)	16	101	88	1	206
TS RUBY	(14W)	8	52	52	-	112
TY SKIP	(02C)	20	118	-	-	138
TY TESS	(15W)	12	86	54	-	152
TS VAL	(16W)	3	64	-	-	67
TS WINONA	(17W)	-	47	19	3	69
TY ANDY	(18W)	-	60	14	2	76
TY BRENDA	(19W)	21	95	57	4	177
TY CECIL	(20W)	8	70	8	-	86
STY DOT	(21W)	24	144	57	-	225
TS ELLIS	(22W)	14	64	-	3	81
TY FAY	(23W)	31	144	139	-	314
TS GORDON	(24W)	3	86	-	-	89
TY HOPE	(25W)	17	90	-	-	107
TS IRVING	(26W)	3	59	-	-	62
TOTAL		349	2505	1360	54	4268
% OF TOTAL NR OF FIXES		8.2	58.7	31.9	1.2	100.0

NORTH INDIAN OCEAN	SATELLITE	TOTAL
TC 01B	36	36
TC 02A	25	25
TC 03B	26	26
TC 04B	20	20
TC 05B	30	30
TC 06B	58	58
TOTAL	195	195
% OF TOTAL NR OF FIXES	100.0	100.0

TABLE 2-4b. FIX PLATFORM SUMMARY FOR 1985

FIX PLATFORM SUMMARY

THE SOUTH PACIFIC AND SOUTH INDIAN OCEANS.	SATELLITE	RADAR	SYNOPTIC	TOTAL
TC 01S ----	41	-	-	41
TC 02S BOBALAHY	63	-	-	63
TC 03S EMMA	48	-	1	49
TC 04P ----	51	-	-	51
TC 05S FRANK	64	8	1	73
TC 06P ----	25	-	2	27
TC 07P MONICA	43	-	-	43
TC 08P ----	47	-	-	47
TC 09P DRENA	20	-	-	20
TC 10S CELESTINA	56	-	1	57
TC 11P ERIC	61	-	-	61
TC 12S ----	29	-	-	29
TC 13P NIGEL	75	-	-	75
TC 14P ODDETTE	65	-	-	65
TC 15S DITRA	36	-	-	36
TC 16P FREDA	26	-	-	26
TC 17S GERTIE	17	-	-	17
TC 18P ----	66	-	-	66
TC 19S ESITERA	36	-	3	39
TC 20S HUBERT	87	-	-	87
TC 21S FELIKSA	32	-	1	33
TC 22S ISOBEL	92	-	-	92
TC 23S GERIMENA	86	-	-	86
TC 24S ----	21	-	-	21
TC 25S JACOB	121	-	-	121
TC 26P PIERRE	46	-	-	46
TC 27P GAVIN	58	-	-	58
TC 28S KIRSTY	98	-	-	98
TC 29S LINDSAY	30	-	-	30
TC 30P HINA	90	-	-	90
TC 31P SANDY	116	-	-	116
TC 32P TANYA	86	-	1	87
TC 33S HELISAONINA	51	-	-	51
TC 34S GRETEL	53	8	1	62
TC 35S MARGOT	87	-	-	87
TOTAL	2023	16	11	2050
% OF TOTAL NR OF FIXES	98.7	0.8	0.5	100.0

also indicated. (Table 2-4b provides the same information for the South Pacific and South Indian Oceans.)

Annex A includes individual fix data for each tropical cyclone in the western North Pacific and North Indian Oceans. (Additionally, it includes individual fix data for each tropical cyclone in the South Pacific and South Indian Oceans.) Fix data are divided into four categories: satellite, aircraft, radar, and synoptic. Those fixes labeled with an asterisk (*) were determined to be unrepresentative of the surface center and were not used in determining the best tracks. Within each category, the first three columns are as follows:

FIX NO. - Sequential fix number

TIME (Z) - GMT time in day, hours, and minutes

FIX POSITION - Latitude and longitude to the nearest tenth of a degree

Depending on the category, the remainder of the format varies as follows:

a. Satellite

(1) ACCRY - Position Code Number is used to indicate the accuracy of the fix position. A "1" or "2" indicates relatively high accuracy and a "5" or "6" relatively low accuracy (reference Table 2-2, Postion Code Numbers).

(2) DVORAK CODE - Intensity evaluation and trend (Figure 2-2, Table 2-5). (For specifics, refer to NOAA Technical Report NESDIS 11.)

(3) COMMENTS - For an explanation of the contractions, see pages vi and vii.

(4) SITE - ICAO call sign of the specific satellite tracking station.

b. Aircraft

(1) FLT LVL - The constant pressure surface level, in millibars, or altitude, in feet, maintained during the penetration. The usual flight level flown in developing tropical cyclones is 700 mb, due to turbulence considerations. Low-level missions are normally flown at 1500 ft (457 m).

(2) 700 MB HGT - Minimum height of the 700 mb pressure surface within the vortex recorded in meters.

(3) OBS MSLP - If the surface center can be visually detected (e.g., in the eye), the minimum sea-level pressure is obtained by a dropsonde release above the surface vortex center. If the fix is made at the 1500-foot level, the sea-level pressure is extrapolated from that level.

(4) MAX-SFC-WND - The maximum surface wind (knots) is an estimate made by the ARWO based on sea state. This observation is limited to the region of the flight path and may not be representative of the entire tropical cyclone. Availability of data is also dependent upon the absence of undercast conditions and the presence of adequate illumination. The positions of the maximum flight level wind and the maximum observed surface wind do not necessarily coincide.

(5) MAX-FLT-LVL-WND - Wind speed (knots) at fight level is measured by the AN/APN 147 doppler radar system aboard the WC-130 aircraft. This measurement may not represent the maximum flight level wind associated with the tropical cyclone

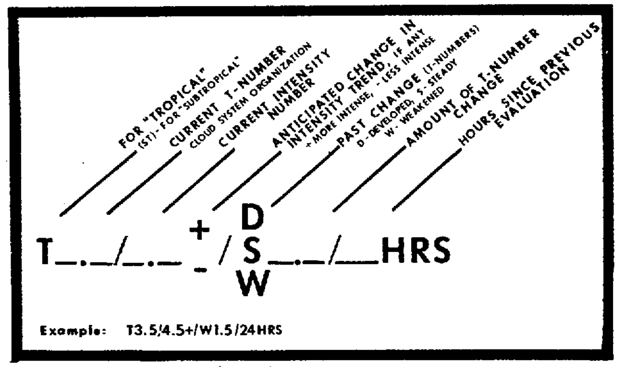


Figure 2-2. Dvorak code for communicating estimates of current and forecast intensity derived from satellite data. In the example the current T-number is 3.5 but the current intensity estimate is 4.5 (equivalent to 77 kt). The cloud system has weakened by 1.5 T-numbers since the previous evaluation conducted 24 hours earlier. The plus (+) symbol indicates an expected reversal of the weakening trend or very little further weakening of the tropical cyclone during the next 24-hour period.

TABLE 2-5. MAXIMUM SUSTAINED WIND SPEED (KT) AS A FUNCTION OF DVORAK CI & FI (CURRENT & FORECAST INTENSITY) NUMBER AND MINIMUM SEA-LEVEL PRESSURE (MSLP)

TROPICAL CYCLONE INTENSITY NUMBER	WIND SPEED	MSLP (NW PACIFIC)
0.0	<25	--
0.5	25	--
1.0	25	--
1.5	25	--
2.0	30	1000
2.5	35	997
3.0	45	991
3.5	55	984
4.0	65	976
4.5	77	966
5.0	90	953
5.5	102	941
6.0	115	927
6.5	127	914
7.0	140	898
7.5	155	879
8.0	170	858

because the aircraft only samples those portions of the tropical cyclone along the flight path. In many instances, the flight path is through the weakest sector of the tropical cyclone. In areas of heavy rainfall, the doppler radar may track energy reflected from precipitation rather than from the sea surface, thus, preventing accurate wind speed measurement. In obvious cases, such erroneous wind data will not be reported. In addition, the doppler radar system on the WC-130 restricts wind measurements to drift angles less than or equal to 27 degrees if the wind is normal (perpendicular) to the aircraft heading.

(6) ACCY - Fix position accuracy. Both navigational (OMEGA and LORAN) and meteorological (by the ARWO) estimates are given in nautical miles.

(7) EYE SHAPE - Geometrical representation of the eye based on the aircraft radar presentation. The eye shape is reported only if the center is 50 percent or more surrounded by wall cloud.

(8) EYE DIA/ORIENTATION - Diameter of the eye in nautical miles. When an elliptical eye is present, the lengths of the major and minor axes and the orientation of the major axis are respectively listed. When concentric eye walls are present, each diameter is listed.

c. Radar

(1) RADAR - Specific type of platform (land, aircraft, or ship) utilized for fix.

(2) ACCY - Accuracy of fix position (good, fair, or poor) as given in the WMO ground radar weather observation code (FM20-V).

(3) EYE SHAPE - Geometrical representation of the eye given in plain language (circular, elliptical, etc.).

(4) EYE DIA - Diameter of eye given in kilometers.

(5) RADOB CODE - Taken directly from WMO ground weather radar observation code FM20-V. The first group specifies the vortex parameters, while the second group describes the movement of the vortex center.

(6) RADAR POSITION - Latitude and longitude of tracking station given in tenths of a degree.

(7) SITE - WMO station number of the specific tracking station.

d. Synoptic

(1) INTENSITY ESTIMATE - An estimate of the tropical cyclone's maximum sustained surface wind in knots is based on the tropical cyclone forecaster's analysis of low-level synoptic data.

(2) NEAREST DATA - The accuracy of a synoptic fix is based on the distance in nautical miles from the estimated fix position to the nearest synoptic report or to the average distance of reports in data sparse areas.

(3) COMMENTS - For an explanation of the contractions see pages vi and vii.